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IS 11297-2 (1988): Varnished fabrics for electrical purposes, Part 2: Methods of tests [ETD 2: Solid Electrical Insulating Materials and Insulation Systems]



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“Knowledge is such a treasure which cannot be stolen”

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Indian Standard

**SPECIFICATION FOR
VARNISHED FABRICS FOR
ELECTRICAL PURPOSES**

“पुनर्षष्ट १९८५”
“RE-AFFIRMED 1985”

PART 2 METHODS OF TESTS

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NEW DELHI 110002

Indian Standard

SPECIFICATION FOR VARNISHED FABRICS FOR ELECTRICAL PURPOSES

PART 2 METHODS OF TESTS

0. FOREWORD

0.1 This Indian Standard (Part 2) was adopted by the Bureau of Indian Standards on 26 July 1988, after the draft finalized by the Solid Electrical Insulating Materials Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard is being brought out in a series of standards on varnished fabrics for electrical purposes. This series will cover the following in various parts:

- a) Definitions and general requirements,
- b) Methods of test, and
- c) Specifications for individual materials.

0.3 This standard (Part 2) covers the methods of test for varnished fabrics for electrical purposes.

0.4 Varnished cotton cloth and tape for electrical purposes at present, covered in IS : 3352-1965*, will be withdrawn at a later date with the publication of relevant specifications in Part 3 for these tapes in the above series.

0.5 In preparing this standard, assistance has been derived from IEC Publication 394-2 (1972) 'Varnished fabrics for electrical purposes: Part 2 Methods of test', issued by the International Electrotechnical Commission (IEC).

0.6 In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960†.

*Specification for varnished cotton cloth and tape for electrical purposes.

†Rules for rounding off numerical values (revised).

1. SCOPE

1.1 This standard (Part 2) covers the methods of test for checking the requirements of varnished fabrics for electrical purposes.

2. GENERAL NOTES ON TESTS

2.1 Test specimens to be selected should represent the bulk of the material.

2.2 Samples shall be subjected for at least 24 h to a standard atmosphere at a temperature of $27 \pm 2^\circ\text{C}$ and relative humidity 65 ± 2 percent before the test specimens are removed for test.

2.2.1 If the test is not conducted in the standard atmosphere, the test shall be conducted within 5 minutes after removal from the standard atmosphere.

3. THICKNESS

3.1 Test Apparatus

3.1.1 A dead weight dial-type micrometer having two ground and lapped concentric circular surfaces flat to within 0.001 mm and parallel

to within 0.003 mm. The upper surface shall be 6 to 8 mm in diameter. The lower surface shall be larger than the upper one. The upper surface shall move on the axis perpendicular to the surfaces. The dial shall be graduated to read directly to 0.002 mm. The frame of the micrometer shall be of such rigidity that a force of 15 N applied to the dial housing, out of contact with either the weight or the presser foot spindle, will produce a deflection of the frame not greater than 0.002 mm as indicated on the micrometer dial. The pressure exerted on the specimen shall be 10 N/cm².

3.1.2 An external screw type micrometer having measuring faces of 6 to 8 mm diameter. The measuring faces shall be flat within 0.001 mm and parallel to within 0.003 mm. The pitch of the screw shall be 0.5 mm and the graduations shall be 50 divisions of 0.01 mm, enabling readings to be estimated to 0.002 mm. The pressure exerted on the specimens shall be 10 to 20 N/cm².

3.1.3 The setting gauge used to check the instruments shall be accurate to within ± 0.001 mm of nominal size.

The indicated thickness of the instruments shall not differ by more than 0.005 mm from the gauge block.

It is preferred that the dead weight micro-meter be employed.

3.2 Test Specimens

3.2.1 Full Width Material — One specimen, 25 mm wide and with its length equal to the width of the roll, shall be cut across the entire width of the roll.

3.2.2 Slit Material — One specimen 1 m long shall be cut from the roll.

3.3 Procedure — Take the measurement of thickness of the material, when not constrained in any way, at nine points. These should be spaced not less than 75 mm apart along the length of the test specimens. Take care to ensure that all joints or selvages shall be excluded from the area of the test.

3.4 Results — Report the central value as well as the maximum, and the minimum value of the nine measurements of thickness in millimetres.

4. EFFECT OF FABRIC ON OIL

4.1 Procedure

4.1.1 Approximately 10 g of varnished fabric is cut into pieces with an area of approximately 50 mm² and placed in a vessel with transformer oil (*see Note*). The mass ratio of varnished fabric to oil should be 1 : 10.

4.1.2 The vessel is placed into a thermostatic bath at a temperature of 105 ± 2°C for 72 h.

4.1.3 Another vessel with the same quantity of oil without varnished fabric is placed in thermostatic bath simultaneously.

4.1.4 Take 50 ml of mixture of toluene and ethyl alcohol in the ratio of 2 : 1. Place the mixture in a conic bulb and boil with a reflux condenser for 5 min.

4.1.5 Take 4 to 5 drops of phenolphthalein indicator and add, the contents are neutralized while hot with 0.05 molar alcoholic solution of KOH till the first appearance of discoloration to pink.

4.1.6 Add 8 to 10 g of transformer oil which has been heated with the varnished fabric, into the bulb. The contents of the bulb are boiled for 5 min with a reflux condenser at continuous mixing.

4.1.7 Add 4 to 5 drops of phenolphthalein indicator and the titrate the mixture while hot with 0.05 molar alcoholic solution of KOH with continuous mixing up to the first appearance of change of colour of the lower layer of the mixture to pink.

4.1.8 The test is repeated using the oil which has been heated without varnished fabric (blank test).

NOTE — The transformer oil used shall fulfil the requirements for transformer oil as given in IS : 335-1983*.

4.2 Results — The acid number of the tested oil is calculated by the formula:

$$\frac{(V_1 - V_2) \times T \times 56.10}{m} \text{ mg KOH/g oil}$$

where

V_1 = volume of solution of KOH used for titration of tested oil, in ml;

V_2 = volume of solution of KOH used for titration in the blank test in ml;

T = titre (molarity) of solution of KOH, in this case 0.05 mol/litre; and

m = mass of the tested oil in g.

The acid number is calculated as the arithmetical mean from the results of two parallel determinations of titration.

5. EFFECT OF OIL OR OTHER LIQUID ON VARNISHED FABRIC

5.1 Test Specimens

5.1.1 Five specimens approximately 125 mm in length and 40 mm in width are taken.

5.1.2 Where the material is less than 40 mm wide, it shall be tested in the width supplied; the length must then be chosen so that a wrapping according to 5.2 can be produced.

5.2 Procedure

5.2.1 Each strip shall be helically wound on to a metal rod of about 10 to 12 mm diameter with an overlap of about 50 percent with the ends fixed and to cover a length of rod of 100 mm.

5.2.2 The rods shall be immersed in a glass vessel filled with the liquid under test and heated in an electrical drying oven at 105 ± 2°C for 48 h.

5.2.3 Uncoiling shall be carried out immediately after the specimen has cooled down to room temperature.

5.2.4 The surface condition is examined for tackiness, transfer of varnish, and swelling.

5.3 Results — The character of damage, if any, is reported.

6. TENSILE STRENGTH AND EXTENSION

6.1 Test Apparatus — Either a constant rate of load machine or a constant rate of traverse

*Specification for new insulating oils (third revision).

machine may be used, the machine preferably shall be power driven and graduated so that a reading of 1 percent of the value required by the specification sheet is possible.

6.2 Test Specimens

6.2.1 Five specimens shall be used each of such a length that it allows a length of 200 mm between the jaws of the testing machine. The width shall be 15 mm, *Max*.

6.2.2 When testing full width straight cut material, cut five test specimens in the direction of the warp and five test specimens in the direction of the weft in such a way as to be representative of the bulk of the material and so that no two test specimens cut in the same direction contain the same longitudinal threads.

6.2.3 When testing full width bias cut material, the specimens are cut in the lengthwise direction of the material in such a way as to be representative of the bulk of the material.

6.2.4 Slit material is tested in the width as delivered up to a maximum of 15 mm.

6.3 Procedure

6.3.1 Fix a test specimen in the testing machine and apply the load in such a way that the time from the commencement of the application of the load to the moment at which the load corresponding to the specified minimum tensile strength is reached in 60 ± 10 s.

6.3.2 Continue until the specimen breaks.

6.3.3 Note the loads necessary to produce extension of 6 percent and 10 percent, the breaking load and also the elongation at break.

6.3.4 If the test specimen breaks unevenly, or in or at the testing machine, discard the result and make a further test using another test specimen.

6.3.5 When the tensile strength of a joint is to be determined, position the joint approximately midway between the jaws.

6.4 Results

6.4.1 Tensile Strength — Take the central value of the five loads at break and calculate the tensile strength of the material expressed in N per 10 mm of width.

6.4.2 Stress at 6 and 10 Percent Extension — Take the central value of the loads producing 6 and 10 percent extension, respectively. Express the stress in N per 10 mm of width.

6.4.3 Elongation at Break — Take the central value of the five values as the elongation at break, expressed in percent of the specimen length between the jaws.

7. INTERNAL TEARING RESISTANCE

7.1 Test Apparatus — Use a falling pendulum tear tester (type Elmendorf) or some other apparatus which suits the test as in Fig. 1.

7.2 Test Specimens

7.2.1 Five test specimens are used.

7.2.2 Each specimen shall be approximately 100×63 mm with the longer dimension parallel to the warp threads and five test specimens shall be of the same size with the longer dimension parallel to the weft threads.

7.2.3 Cut one slit in each test specimen with a suitable slitting device (which is usually provided with the testing instrument) in the middle of one of the 100 mm edges.

7.2.4 The distance from the end of the slit to the uncut 100 mm edge of the specimen (that is the length to be torn) shall be 43.00 ± 0.15 mm. The length of the slit is not critical.

7.2.5 If the material is also to be tested after heating in air, another set of ten specimens from each direction is needed.

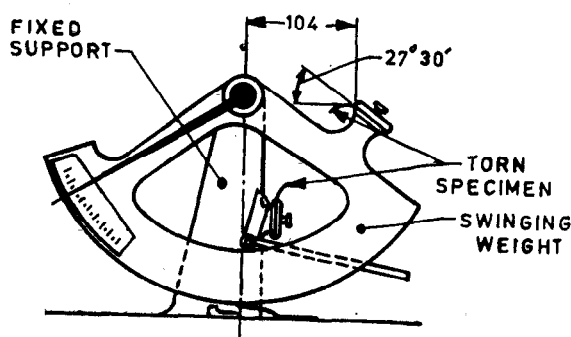
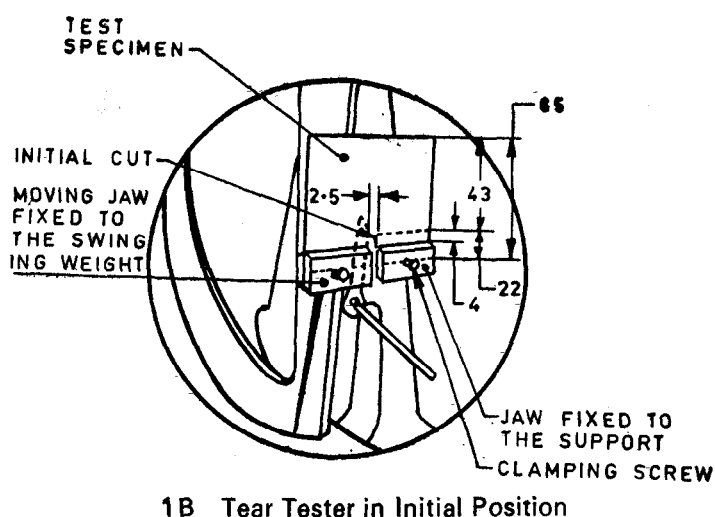
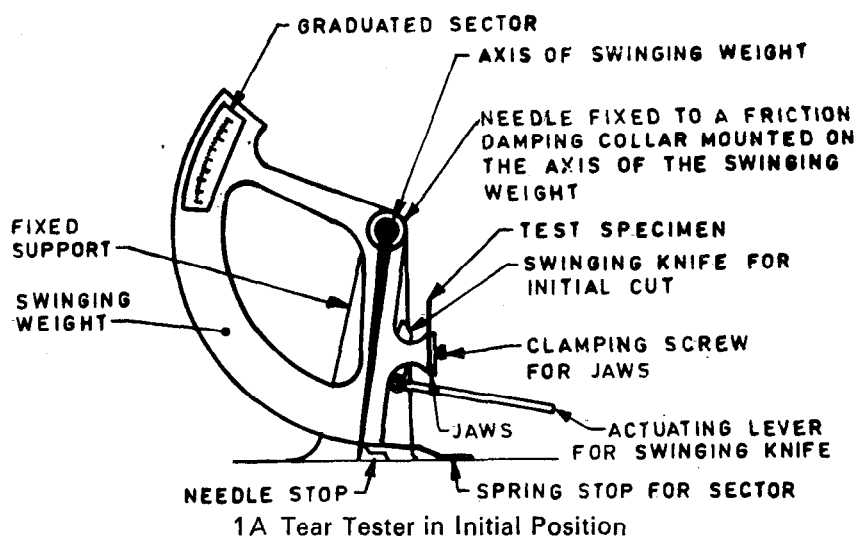
7.3 Procedure

7.3.1 In this test, conditioning is very important as described in 2.

7.3.1.1 Material as received — Raise the pendulum to the starting position and set the pointer against its stop. Fasten the specimen securely in the clamps so that it is well centred with the bottom edge carefully set against the stops and so that the upper edge is parallel to the top of the clamps and the width-wise yarns are exactly perpendicular to them. Close the clamps by tightening the set screws, using approximately the same force on both the clamps. The specimen should lie free with its upper area directed towards the pendulum so as to ensure a shearing action. Release the pendulum. Hold down the pendulum stop until after the tear is completed and catch the pendulum on return swing with the hand, without disturbing the position of the pointer. Read the scale to the nearest whole scale division.

7.3.1.2 Material after heating in air — Condition five of the test specimens for 1 h and the remaining five test specimens for 48 h in an oven with forced circulation. The air in the oven shall be circulated within the oven with sufficient admixture of outside air so that the total volume of air is replaced at least four times per hour. The oven temperature shall be chosen from the list of IS : 2260-1973* and defined in the specification on individual materials of this

*Preconditioning and testing of solid electrical insulating materials (first revision).



All dimensions in millimetres.

FIG. 1 DIAGRAM OF AN ELMENDORF TEAR TESTER

standard on individual materials. Allow to cool to room temperature in normal atmosphere, and test according to 7.3.1.1 within one hour.

7.4 Results

7.4.1 Calculate the tearing strength of a test specimen in N by multiplying the actual reading of the scale by the constant of the instrument.

7.4.2 Report the central values and the maximum and minimum values of tearing strength of each sample of five specimens tested according to 7.3.1.

7.4.3 Express the tearing strength in N to two decimal places.

7.4.4 If the tearing strength is greater than the maximum capacity of the instrument, the result shall be expressed as greater than this value.

8. EDGE TEARING RESISTANCE

8.1 Apparatus — A testing machine as described in 6.1 equipped with a fixture shown in Fig. 2.

8.2 Test Specimens — Nine specimens each approximately 300 mm in length and maximum 15 mm in width shall be taken.

8.3 Procedure

8.3.1 The test specimen is inserted into the inclined slot of the fixture which is clamped into the upper clamp of the tensile testing machine.

8.3.2 The two ends of equal length are clamped into the lower clamp of the machine.

8.3.3 The sample is lightly pressed from above by a rubber pad adjustable by a screw to prevent it slipping within the inclined slot of the fixture.

8.3.4 The time from the beginning of the stress until the tearing of the sample shall be 20 ± 5 s.

8.3.5 Read off the force at which the tearing of the edge begins.

8.4 Results — Report the central value of the nine measurements in N.

9. ELECTRIC STRENGTH

9.0 The test shall be carried out in accordance with IS : 2584-1963*.

9.1 Apparatus

9.1.1 General Requirements on the Test Apparatus — The apparatus and electrodes shall be in accordance with IS : 2584-1963*, and the faces of the electrodes shall be parallel and free from pits of other imperfections. Figure 3 shows a convenient arrangement.

9.1.2 Apparatus and Electrodes for Extended Materials

9.1.2.1 Suitable means for stretching tapes may be added in the apparatus, as described in 9.1.1. A possible arrangement is shown in Fig. 4.

9.1.2.2 The apparatus for stretching is a rigid frame carrying two similar clamps not less than 330 mm apart on opposite sides.

9.1.2.3 Adjacent to one clamp is a rod which can be rotated by means of a handle and to which the test specimen can be attached. For extension, the frame can accommodate more than one test specimen, a number of clamps being arranged on the two opposite sides.

9.1.2.4 The frame is mounted so that the extended test specimen is 50 mm above the testing table, or base board, to coincide with the tops of the lower electrodes in the electrode assembly described in 9.1.1.

*Method of test for electric strength of solid insulating materials at power frequencies.

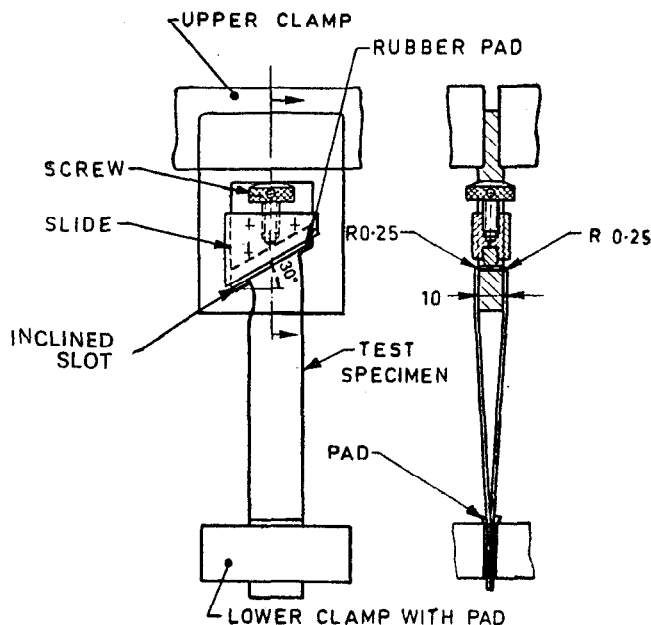
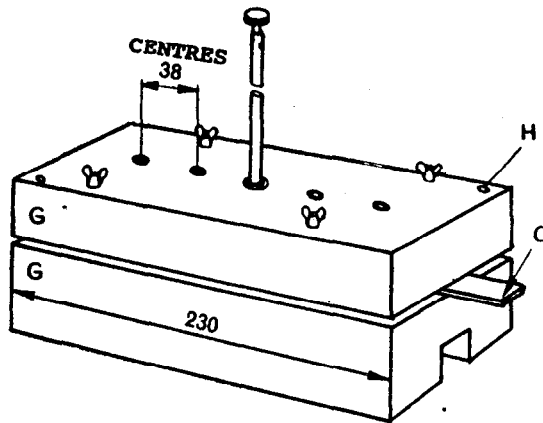
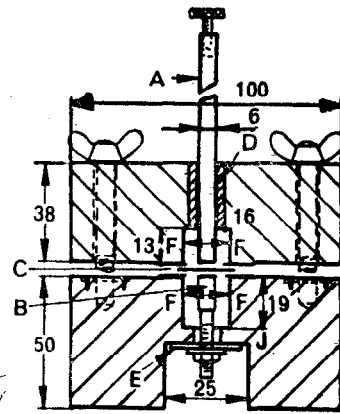


FIG. 2 FIXTURE FOR APPARATUS FOR MEASURING EDGE TEARING RESISTANCE



3A General Arrangement of Apparatus

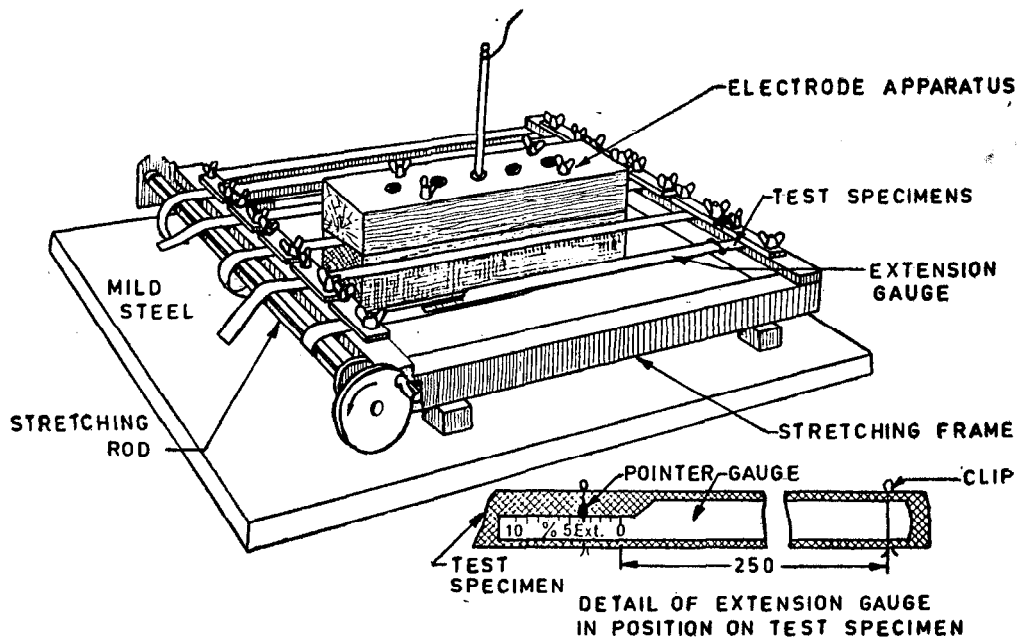


3B Section of Apparatus Through Electrodes with Top Slightly Raised

- A = Upper electrode to be an easy fit in bush D
 B = Lower electrode
 C = Specimen under test
 D = Brass bush with inside diameter just sufficient to clear 6 mm rod
 E = Brass strip 25 mm wide connecting all lower electrodes
 F = Pieces of varnished cloth strip overlapping edges of specimen
 G = Blocks of suitable insulating material, for example, a paper filled laminate
 H = Dowel hole
 J = Brass bushing with internal thread

All dimensions in millimetres.

FIG. 3 TYPICAL EXAMPLE OF ELECTRODE APPARATUS FOR TESTS ON TAPE



All dimensions in millimetres.

FIG. 4 APPARATUS FOR STRETCHING AND TESTING EXTENDED SLIT MATERIAL FOR ELECTRIC STRENGTH

9.1.2.5 The extension of the test specimen may be measured by a light gauge of paper or aluminium approximately 290 mm long, fastened to the test specimen by wire, clamped about 25 mm from one clamp. The opposite end of the gauge is marked in percentage extension commencing 250 mm from the clamp. A light pointer is attached to the test specimen at the other gauge mark before it is extended and the appropriate extension is read off the gauge as the test specimen is stretched.

9.2 Test Specimens and Number of Tests

9.2.1 All specimens shall be 450 mm in length and 25 mm in width.

9.2.2 The number of tests shall be five in accordance with IS : 2584-1963*.

9.2.3 These five tests can be done on the same specimen. If any test result deviates by more than 15 percent from the central value, five additional tests shall be made.

9.2.4 When testing materials narrower than 25 mm, an arrangement should be made to avoid flashover.

9.3 Procedure

9.3.1 Electric Strength at Room Temperature

9.3.1.1 Condition the test specimens for 48 h in the standard atmosphere 27°C and 65 percent RH. The test shall be made within 5 minutes of removal of each test specimen from the controlled atmosphere.

9.3.1.2 The application of voltage shall be in accordance with IS : 2584-1963* (short-time test).

9.3.1.3 Criteria of breakdown shall be according to IS : 2584-1963*.

9.3.2 Electric Strength of Elevated Temperature

9.3.2.1 Heat the specimens for 10 min in an oven at the temperature specified in the specification sheet before placing the electrodes, already heated to that temperature, in position.

9.3.2.2 Maintain the specimens and the electrodes at that temperature throughout the test carried out as described in 9.3.1. The temperature shall be measured by suitable means on the bottom of a dummy upper-electrode.

9.3.3 Electric Strength of Extended Material

9.3.3.1 Condition the test specimens as described in 9.3.1. Stretch each specimen at $27 \pm 2^\circ\text{C}$, or within 5 minutes after removal from the controlled atmosphere, to the specified extension in the apparatus mentioned in 9.1.2.

*Method of test for electric strength of solid insulating materials at power frequencies.

9.3.3.2 Maintain the test specimens at $27 \pm 2^\circ\text{C}$ for not less than 10 minutes and not more than 30 minutes, and insert them into the electrode assembly while still under mechanical tension.

9.3.3.3 Apply the voltage in accordance with IS : 2584-1963* at $27 \pm 2^\circ\text{C}$ or within five minutes of removal from the controlled atmosphere.

9.3.3.4 The criteria of breakdown shall be according to IS : 2584-1963*.

9.3.4 Electric Strength of Material After Folding

9.3.4.1 Condition the specimens as described in 9.3.1.

The specimen is folded back over a number of thicknesses of the material under test, the actual number being specified in Part 3 of this standard.

9.3.4.2 To make the fold, a roller 35 mm in width, 50 mm in diameter exerting a total force of 20 N is passed along the fold with one edge of the roller overhanging the fold by 1 to 2 mm.

9.3.4.3 Unfold the specimens and clamp the specimens between the electrodes with the fold line under the centre line of the electrodes and apply the voltage in accordance with IS : 2584-1963*.

9.3.4.4 The criteria of breakdown shall be according to IS : 2584-1963*.

9.3.5 Electric Strength After Conditioning at 93 Percent RH for 96 h at 27 or 40°C

9.3.5.1 Condition the specimens for 96 h in an atmosphere of 93 ± 2 percent RH at a temperature of $27 \pm 2^\circ\text{C}$ or $40 \pm 2^\circ\text{C}$ as prescribed in Part 3 of this standard for individual materials.

9.3.5.2 Apply the voltage within five minutes of removal of each specimen from the controlled atmosphere in accordance with IS : 2584-1963*.

9.3.5.3 The criteria of breakdown shall be according to IS : 2584-1963*.

9.4 Results — The report shall be in accordance with IS : 2584-1963*. The central value shall be taken as the result. The results shall be reported in volts (breakdown voltage).

10. THERMAL ENDURANCE

10.1 Any of the following three methods of tests for determination of thermal endurance of insulating varnishes may be employed:

IS : 11256 (Part 1) - 1985 Electric strength methods

*Method of test for electric strength of solid insulating materials at power frequencies.

IS : 11256 (Part 2)-1985 By measurement of loss of mass

IS : 11256 (Part 3)-1985 By measurement of bond strength by helical coil method

thickness borosilicate test tube. The dimensions of this tube shall be approximately 125 mm long by 16 mm diameter (see Fig. 5). Add 2 ml of distilled water to the test tube.

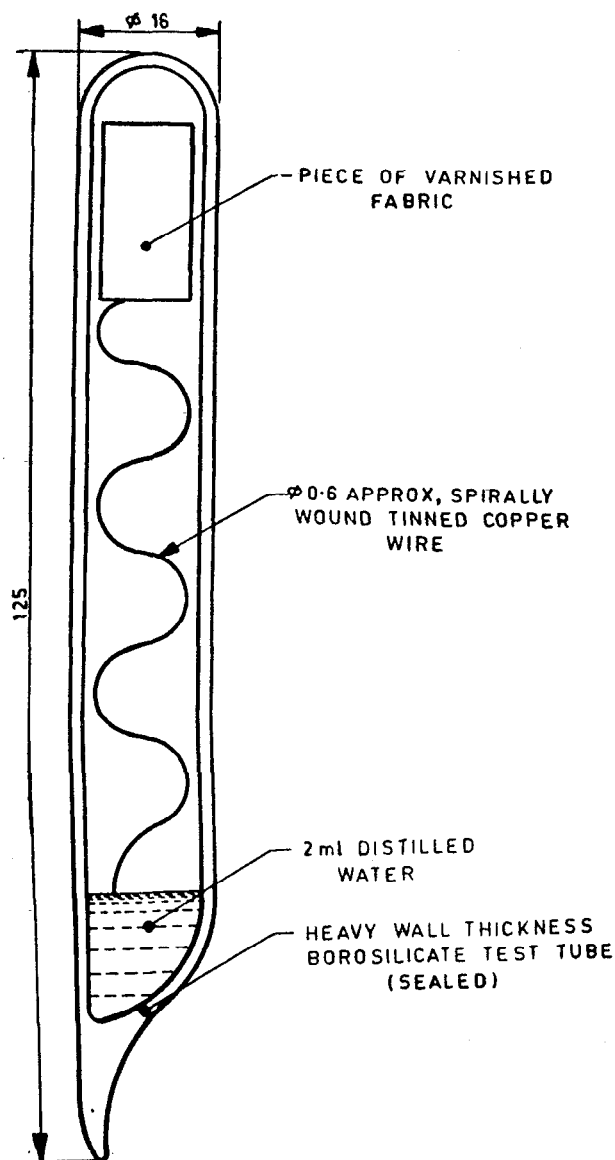
11. RESISTANCE AGAINST HYDROLYSIS

11.1 Test Specimens — A piece of varnished fabric, approximately 125×50 mm or an equivalent area of narrower material shall be used as the test specimen.

11.2 Procedure

11.2.1 The test specimen should be rolled. Push the rolled specimen into a 'heavy' wall

11.2.2 Take a short length of tinned copper wire, approximately 0.6 mm diameter, and with the end nearest the test specimen bent into circular shape at a right angle to length. Insert the wire into the test tube. Cut the wire at such a length that it is totally within the test tube and acts as a stop to ensure that the specimen does not slip into water when the test tube is sealed and inverted.



All dimensions in millimetres.

FIG. 5 A TYPICAL BOROSILICATE TEST TUBE

11.2.3 The sealing of the test tube can be done by drawing it out in a flame ensuring while sealing that the wall thickness of the test tube is not reduced unduly.

11.2.4 Place the test tube (when cold) vertically, with the sealed end downwards, in an oven and maintain it at $105 \pm 2^{\circ}\text{C}$ for the time prescribed in Part 3 of this standard on individual materials.

11.2.5 It is essential that 'heavy' wall thickness test tubes are used for this test to minimize the risk of explosion and injury to personnel. As a

further safety precaution, it is recommended that the test tubes are screened from the observer.

11.3 Results — Observe the test specimen from time to time and at the end of the appropriate period, for signs of flow of the varnish film. The varnish shall show no well marked flow. Where the specified time is reached without well marked flow, the specimen shall be withdrawn from the test tube and its surface condition examined for tackiness, transfer of varnish during unrolling, and swelling. All these observations shall be reported.